Agricultural Information Dissemination using ICTs: A Review and Analysis of Information Dissemination Models in China

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Abstract

Over the last three decades, China's agriculture sector has been transformed from the traditional to modern practice through the effective deployment of Information and Communication Technologies (ICTs). Information processing and dissemination have played a critical role in this transformation process. Many studies in relation to agriculture information services have been conducted in China, but few of them have attempted to provide a comprehensive review and analysis of different information dissemination models and their applications. This paper aims to review and identify the ICT based information dissemination models in China and to share the knowledge and experience in applying emerging ICTs in disseminating agriculture information to farmers and farm communities to improve productivity and economic, social and environmental sustainability. The paper reviews and analyzes the development stages of China's agricultural information dissemination systems and different mechanisms for agricultural information service development and operations. Seven ICT-based information dissemination models are identified and discussed. Success cases are presented. The findings provide a useful direction for researchers and practitioners in developing future ICT based information dissemination systems. It is hoped that this paper will also help other developing countries to learn from China's experience and best practice in their endeavor of applying emerging ICTs in agriculture information dissemination and knowledge transfer.

1. Introduction

Agriculture plays a significant role for economic and social development in most undeveloped countries. Information of adequate quality is a necessary condition for improvement of all areas of agriculture [17]. With the rapid development of Information and Communication Technologies (ICTs), data and information can be effectively generated, stored, analyzed, disseminated and used to support farmers and farming communities to improve agricultural productivity and sustainability. Information services for farmers at the national and regional level are a promising new field of research and application in the emerging field of e-agriculture [5]. Informatization refers to the transformation of an economy and society through the effective deployment of information and communication technologies in business, social, and public functions [6,22]. It has been a significant phenomenon in China [6,22]. Agricultural Informatization, which is a specific term used in China, has no official definition [13]. Based on Li *et al* [8,9], it can be defined as the degree and process of transforming Agriculture sector through the effective use of ICTs in agricultural production, operation, and management. Li [7-9] has published a series of reports on rural informatization in China and provided a useful overview on informatization progress, achievements and policy implications at the national and local levels. However, Liu [13] argues that existing research on China's agricultural informatization is still fragmented and exploratory.

With the introduction of agricultural informatization, the traditional agriculture has been reformed by advanced ICTs, eventually contributing to the significant improvements in agricultural productivity and sustainability. Agricultural informatization is a long-term stimulus for agricultural development and also an important indicator of agricultural modernization. The agricultural information dissemination service is one of the critical missions in implementing agricultural informatization [9] and [2]. China is seeing a rapid growth in its economy, and farmers are achieving a dominating role in the economic development. To improve agriculture productivity, farmers have an ever increasing demand for information because accessing information and knowledge is essential for improving their productivity and income. In particular, since China became a member of World Trade Organization (WTO), its agricultural industry has been strongly affected by markets, resources, and environments. Facing the fierce competition both in the domestic and international markets, Chinese farmers and agri-business managers must be fully aware of the available emerging technologies as well as markets and sales information to maximize economic benefits. Therefore, over the last three decades, Chinese government has invested substantial amount of effort and money to develop and deploy ICT-based agriculture information dissemination systems nationwide [9]. As a result, many innovative and effective information dissemination models have been emerged and widely used. Farmers have gained enormous benefits from the information dissemination services provided. A few studies in relation to agriculture information services models have been conducted in China [e.g. 26], but none of them have attempted to provide a focused and comprehensive review and analysis of different information dissemination models and their applications. This paper aims to review and identify ICT based information dissemination models in China, and most importantly, to share the China's experience and best practice in applying emerging ICTs in disseminating agriculture information to farmers and farming communities.

2. Agricultural Information Service Development History

Driving by the emerging trend of market-based reform and informatization, Chinese agricultural information dissemination service systems were transformed from traditional pattern to market and economy based framework. From the perspective of agricultural information development and applications, the Chinese agricultural information dissemination services experienced a three-stage development process as below [19]:

- Initial developing stage (1970-1990)
- Establishing stage (1990-2000)
- Consolidating and rapid expanding stage (2000 - present)

Initial developing stage

Before year 1990, the initial concept of agricultural *informatization* emerged from the planned economy's requirements for agricultural statistics [22]. In year 1979, China imported its very first mainframe computer for agricultural scientific computing, mathematical planning, statistics analyzing, etc. China set up the first computer application research institute in agriculture in 1981, which was the computer center in the Academy of Agricultural Sciences. The center began the applied research on scientific computing, mathematical planning and statistics analyzing. Chinese Ministry of Agriculture (MOA) equipped every agricultural department with computers in every province in China in 1984

and held three computer knowledge training seminars in order to push the development and application of computer-based information processing in agriculture. In 1987, the Information Center was founded in MOA, to promote applications of computer-based information processing in rural areas.

Establishing stage

From early 1990 to 2000, the central government pushed the informatization strategy in agriculture with strengthened guidance, and information systems. In 1992, MOA conducted 'Rural economic information construction plan' and set up rural economic information system liaison offices to strengthen and coordinate informatization development activities. These measures marked an important point in history. In 1994, MOA set up the Department of Market and Economic Information, accordingly. Liaison offices for informatization was formed in provincial, municipal agriculture departments. In December 1994, during the 3rd conference of 'National Economic Information Joint Meeting', the 'Golden Farming Project (JinNong)' was launched. In 1995, MOA formulated 'The 9th 5-year-plan for Rural Informatization Construction and the Plan for 2010'. The first national agricultural informatization conference was held in 1996. At the end of 1998, the Ministry of Science and Technology (MOST) started 'The national intelligent agricultural informatization technology applications program', and the program won widely supports. Pilot zones were set up in twenty-two provinces. As a result, national networks were developed rapidly and agriculture entered a new era for informatization, with scattered information systems becoming more integrated through networked systems [22].

Rapid expanding stage

Since 2001, agricultural informatization have received great attention by the central government with a series of important policies and guidance published to support it. A number of projects were launched to advance the information systems construction in rural areas nationwide. In addition to the support from the central government, local governments were engaged in implementing local pilot projects in rural informatization construction, including the farmers mailbox in Zhejiang, the 12316 service line for farmers in Liaoning, the agriculture information SMS in Hunan, the soil testing and fertilizers recommendation service in Jilin. As a result, rapid progress was made in improving dissemination services and service models. The information service coverage has significantly increased. For example, up to 2014, there are approximately one million agricultural information service centers and 700,000 agricultural information officers in China [19].

3. Mechanisms of Agricultural Information Service Systems

There are different ways in developing, deploying and managing agricultural information services in China. The service mechanisms can be categorized into three types: government-led, market driven, and community self-support [19]. Each type has its advantages as well as disadvantages. Due to the unbalanced economic development and the differences in regions, it is very important to consider the local characteristics when choosing a suitable dissemination service mechanism.

Government-led

Government has always played an essential role in agriculture development [15]. This model is based

on the fact that government support and services are free of charge and funded by the government budgets. The beneficiary is farmers groups. The rural economic situation is still poor thus the services financed by the government are currently still the main mechanism in China.

The government-led mechanism depends on the government system structure and normally follows a top-down approach. The initiatives are developed from MOA and promoted through the management systems from agricultural departments in provincial cities, agriculture bureau or agricultural promotion centers in counties. They are finally implemented in agricultural stations in villages. The advantages of this hierarchical implementation system are effective control and coordination of resources involved. Also this mechanism has advantages of supporting policies, regulations and adequate human and financial resources. However disadvantages are the government oriented organizations may be lack of effective incentives. The services provided are not always originated from farmers' requirements. As a result, farmers may not be highly motivated to use the services.

It is argued that due to the free services offered by the government to farmers, the government-led mechanism is more suitable for low income farmers in low economic development areas [19].

Market driven

The market driven mechanism refers to the development and provision of information services to individual farmers by commercial enterprises. Farmers pay for the access and use of information, so information service providers can make profit from their investment. Currently the mechanism of using the market driven approach to develop commercial agricultural information service systems in China is still in the preliminary stage because the rural information market is not sufficiently mature due to the risk involved. From a long term perspective, the Chinese agricultural information service can follow the market driven mechanism to ensure sustainable information dissemination services.

The market driven mechanism is suitable for regions where farmers have high financial capability, know their information needs, and are motivated to pay for the valuable information. To stimulate the market driven services and develop the commercial agricultural information market, local governments sometimes also support the agricultural information enterprises with favorable financial incentives and policies, such as local credit and favorable tax, to ensure a healthy environment for the agricultural information market.

The major advantage of this mechanism is that it is demand driven and can be a win-win situation for both information enterprises and farmers. However, relevant regulations need to be developed to protest farmers' right and minimize the commercial companies' risk.

Community support

The community support mechanism is that information services are organized by local communities. They finance the information provision through their own funds. Typical communities are farmers co-operative organization, professional agricultural technology associations, industry associations, etc. The members benefit from the information provided by the community. Because the government policies encourages the development of community self-support approach, it is becoming an popular and important model for rural agricultural information dissemination

The community self-support mechanism must follow certain policies and regulations that are set up by the government. This mechanism is more suitable for well-developed regions where farmers may have certain invest capability as well as information analyzing and processing capabilities. To encourage

the development of this mechanism, local governments sometimes also provide financial incentives for the communities.

4. Agricultural Information Dissemination Models and Case Studies

With the development of information technology, the agriculture information dissemination models are constantly evolved and improved. Currently, the agricultural information dissemination models in China can be classified into the following types:

1. Web Portal – a collection of relevant web sites to form one stop centers for users, e.g. MOA Web Portal, etc.
2. Voice-Based Service – information dissemination through telephone, i.e. call centers, e.g. Liaoning 12316 Golden Farming Hotline.
3. Text (SMS)-Based Service – information dissemination through text message of mobile phones. This service is normally jointly operated by agriculture sector and telecom service providers, e.g. Hunan Agri-Telecom Platform.
4. Self-Support Online Community – information services provided by a community to its members. This is a membership based system involving all stakeholders. Members share experience and exchange information through interactive service platforms, e.g. farmers Mailbox in Zhejiang Province.
5. Interactive Video Conferencing Service – using online multimedia technology to facilitate information service, e.g. Shanghai Farmers "One Click and Go" service, or Intelligent Farmers service.
6. Mobile Internet Based Service – information dissemination through smart phone service, e.g. Agribusiness price information, E-news, etc.
7. Unified Multi-Channel Service Model – utilizing multiple methods to effectively disseminate information through telephones, computers, and mobile phones., e.g. "3 in 1" service in Fujian

To determine what is the most appropriate model to be adopted, the information infrastructure, operating costs, farmers' capabilities, farmers' information consumption behaviour and, most importantly, the local context should be taken into consideration [27, 28]. The following sections analyze the features of each model and demonstrate its applications with case studies. All case studies are based on the official reports received by the MOA's Information Center.

4.1 Web portal

Web Portal is a platform hosting a collection of relevant websites. It is an important and fast information dissemination channel. With the popularization and application of web technologies in agriculture, we see an explosion in the number of agricultural websites created in the last decade. A large number of websites are developed in each province and region. Web Portal is created with a large number of linked sites. All the websites follow unified styles, standards and regulations. The establishment of web portals promotes the sharing and utilization of information resources, reduce overall investment and maintenance costs, and increase the service coverage and site visits.

Case study: MOA Web Portal

The web portal of Ministry of Agriculture was established in 1996. It was the first ministry website to establish access to the Internet. The MOA web portal has now contained websites from different bureaus and institutions under MOA's administration. Currently, the MOA web portal includes different types of website, for instance, governance sites and public service sites. In addition to the Chinese native language, English, Japanese, Korean, Russian and other foreign languages are also provided with news, government events, online offices, public interaction, and integrated multiple functions of public information services. The portal has integrated abundant resources from agriculture-related departments, allowing the public to access agricultural news, agricultural market information, agricultural technologies, and rural life and culture information.

Operational features

1. High quality service standards. To ensure the quality and security of information services, MOA issued "Management Regulations for The Ministry of Agriculture Portal (Trial)" in 2011, which clearly defined the roles and responsibilities of each department and unit in website planning, supervision, management, and technical support.
2. Comprehensive management and maintenance mechanism. To guarantee the sustainability of the web portal, MOA requests all relevant business divisions and institutions to specify a designated person responsible for the update of website contents. The Information Center of MOA is responsible for site content planning, information integration and daily operation and maintenance of the portal.
3. Provision of diversified contents to meet the farmers' information needs. The site offers comprehensive and diverse information services, including national and local news released by the agricultural sectors, agricultural market information, agricultural technology, rural life and culture information.

Service Outcome

The impact of the site has been significantly increased over the past years. In the 2013 annual performance evaluation of government websites, hosted by the Website Information Research Center of the Chinese Academy of Social Sciences, MOA portal was ranked third among the State Council Departments. It won the management innovation award, government transparency leadership award, and the internationalization award. The portal has approximately eight million daily visitors from 158 countries and regions. The site traffic outperforms most international agricultural sites including the Food and Agriculture Organization of the United Nations (FAO) official website, and tops all the domestic agricultural sites. The portal focuses on the characteristics of the agricultural sector, and has formed a unified access to other agricultural sites. By integrating with other industry/professional websites, the website has established sub-sites featuring green food, agro-meteorology, and the Internet of Things. It is linked to more than 40 websites for farming, fisheries, farming collaboration and other professional sites, thus enriching the website content both at the industrial and professional levels. The website has improved the level of transparency and openness of MOA. Through the establishment of related business processes, classification criteria, catalog systems, and operation and maintenance system, and by integrating government information resources from the various units of MOA, the website has significantly strengthened information dissemination effectiveness and efficiency.

4.2 Voice based service

The voice service is the use of the call center technology to provide users with expert advice and automated voice services. At present, China's rural telephone penetration rate is on a very high level. According to the National Bureau of Statistics, as of the end of 2012 [20], every 100 rural households have 197.8 mobile phones, 42.2 landline telephones. So the voice service is currently a key channel to get connected with the farmers. Farmers can call in to get information and guidance on policy, technology, marketing, business, or other relevant professional and social information. In July 2006, MOA launched the 12316 hotline to serve Chinese farmers. Up to now, the 12316 hotline has covered 1/3 rural households nationwide [23], and become a well know brand name to provide the direct connection between farmers and experts.

Case study: Liaoning 12316 Golden Farming Hotline

Liaoning 12316 Golden Farming Hotline was put into operation in 2005. It is an integrated information service platform for the agricultural sector worker and farmers. It is the key information engineering project for the national "Eleventh Five-Year" strategy as a "three-in-one" project promoted in Liaoning. The project was jointly constructed by MOA and the Liaoning provincial government. The 12316 hotline has 66 “expert seats”, responding to approximately 3,000 calls every day. At the end of 2013, the hotline had handled 3.62 million cases of farmers’ inquiries, delivered over 9,000,000 words of all kinds of agriculture-related information, broadcasted more than 10,000 television and radio programs (moa.gov.cn).

Operational features

1. Innovative development model. Liaoning 12316 hotline is a joint effort and close collaboration of key stakeholders from government, enterprise, and farmers.
2. Establishment of the 12316 “Cloud” platform. Since 2012, Liaoning has upgraded the platform architecture with cloud technology.
3. Development of a standardized service mechanism to benefit farmers. It has working staff on duty 12 hours every day and 24-hour automated voice service, serving farmers all year around.
4. Professional service team. After years of development and accumulation, it now has a team of more than 200 agricultural experts and 60 consultants in its professional service team.
5. Provision of a wide range of services covering many topics and areas.

Service Outcome

The Liaoning 12316 Golden Farming platform successfully set up a hotline linking farmers to the government, latest technologies, and markets by enabling an efficient information dissemination flow. The platform has effectively consolidated the grassroots information service infrastructure, strengthened the supervision on agriculture subsidies, and safeguarded the agricultural market environment. It has also greatly enhanced agricultural sectors, strengthened the relationships between government and farmers, narrowed the gap between urban and rural areas, and helped farmers to keep up with the latest technology and innovation. It is estimated that this service has helped farmers to generate revenues of about 30 billion yuan (c.a. 4.5 billion pounds) (moa.gov.cn).

4.3 Text (SMS) based service

SMS message service model is operated jointly by agricultural organizations and telecom service providers (SP). The agricultural information provider edits, audits, and publishes text messages through the specified telecommunication channels. Mobile phones have become an important communication media for farmers in managing agricultural production and daily life, and communicating with the outside world. With the increasing number of farmers who own mobile phones, the information dissemination through SMS has become a key service model. In 2009, MOA launched a short messaging services using access code "12316" at all levels of the agricultural sector.

Case study - Hunan Agri-Telecom Platform (HATP)

In 2006, the Hunan Provincial Department of Agriculture and the Hunan Branch of China Mobile signed a strategic agreement to jointly working on agricultural information dissemination by taking advantages of the mobile phone network platform. Both parties made full use of their respective resources, and helped promote the dissemination in the forms of events, websites, posters, text messages and mobile subscription packages. They established the Hunan Agri-Telecom Platform (HATP). Fig. 1 shows the HATP's SMS service page that offers a range of functions and services in a very easy to use and user friendly interface.

Fig. 1. HATP's SMS service page

Operational features

HATP is a joint effort from both government organizations and private companies. The principle of the management and maintenance of this platform can be summarized by a few key words: Led by government, Joined by enterprises, Adapted to the market, Benefiting the farmers. The expert team and the market information reporter team are the most important teams for this service model. 335 experts were employed in the first round with 60 of them being the core experts responsible for information collection and consultation. The 30 market information reporters collect markets, prices, and supply/demand information from various types of sources. The platform highlights a single access to multiple varieties of agricultural information with the lowest cost and highest efficiency.

Service Outcome

From 2007, the Hunan agricultural information service platform has brought enormous benefits with regard to guiding agricultural production, improving agricultural productivity and efficiency. It provides timely and effective technical guidance in dealing with crop drought and frost, pests, etc. and has been highly appraised by the users. Up to 2014, the platform has more than 10,000 items of information released, 3 million phone consultations completed, and 3 million subscribers, resulting in better social and economic benefits.

4.4 Online Community

This is a "bottom-up and participatory approach" [1, page 50]. Research by Yu [25] finds that the most common source of information for Chinese farmers is from acquaintances and relatives. Therefore, online communities provide a platform for farmers and relevant parties to share information. In the online community support service model, farmers and other agents can form a community to help each other. It can also be former-to-farmer community. Farmers register themselves in the service system with authenticated personal information. In this online community service model, members of the communities include farmers government officers, agri-technical professionals, industry associations, and agri-enterprises. They chat online using their computers or mobile phones.

Case study- Farmers'Mailbox in Zhengjiang

In Eastern regions of China, the computer penetration rate is high in rural areas. Farmers in these regions have higher IT literacy and higher usages of Internet compared with the rest of the country. Thus the online community support service model suits those areas very well because farmers carry out regular online communications to share information experience with each other. For example, this model is remarkably successful in Zhejiang province.

Farmers' Mailbox is a public service platform customized to serve local farmers in Zhengjiang. Farmers register themselves with authenticated personal information. The platform provides services in e-commerce, e-government, agricultural services, and information integration. Farmers have an easy access to the platform with computers and mobile phones, chatting with each other, searching information, etc. This platform was developed mainly by Agriculture Department of Zhejiang Province and China Mobile in Zhejiang. Agricultural sector in provincial, municipal and county levels share their respective responsibilities in the management and maintenance of the community platform.

Operational features

1. Rigorous management system. The platform is managed in a hierarchical structure covering the provincial, city, county, township, and village administration. This hierarchical management system guarantees the information reliability.
2. Smooth contact system. The communication network comprises of contact stations at the provincial, city, county, township, and village levels. The platform coverage of stations is 100% at the provincial, city, county, and township level and 95% at the village level.
3. Reliable system with authenticated information. The Farmers' Mailbox project requires real name registration. Members registration is verified by the local authorities to ensure that user information is authentic and reliable.
4. Constant improvement of service quality. More functions are added to the platform over the years to meet the growing and changing requirements from farmers. The user experience is constantly improved by simplifying the operations.

Service Outcome

The mailbox platform serves as a unified agricultural information service platform in Zhejiang, covering five administrative levels. It acts as a window for farmers communities to share information and knowledge, and has brought great economic benefits. The mailbox has played an active role in the development of modern agriculture, improve agricultural efficiency, and help farmers increase income. Traditional onsite agricultural fairs are supplemented by online ones and marketing costs are greatly reduced. The information service has solved the "last mile" problem. Farmer's Mailbox is easily accessible. Online communications save costs compared to traditional telephone use, mail delivery, printing, etc. It is estimated that approximately 180 million yuan is saved in total. At present, Zhejiang farmers mailbox has 2.6 million registered members, forming a stable customer base.

4.5. Interactive Video Conferencing Service

Video conferencing service model is the use of the Internet to achieve real-time video and voice communications. The most notable features of this model lie in a visual and face to face interaction, multiple service approaches including one-to-one service to provide real-time remote technical advice, one-to-many services to provide real-time remote classroom lectures, and many to many services, namely self-serving video courseware. Farmers and agricultural experts can have an online one-to-one interaction. For example, farmers can ask questions and show the pest samples to experts through video camera to help experts offer accurate diagnosis and effective solutions. Fig. 2 shows an example of online video conferencing commination.

Fig. 2. An example screenshot of online video conferencing

Case study – One Click Farmers Service platform in Shanghai

The Information Center of the Agriculture Committee in Shanghai developed the "integrated information service platform for farmers " called "One Click Farmers Service" and deployed intelligent terminals to farmers. The platform collects and disseminates relevant information through the terminals in Shanghai. Information provided covers the policies, agricultural technology promotion, disaster warning, distance education, news of village affairs, expert advice, etc. The platform serves farmers free of charge. The platform also can facilitate a multi-party video chatting, two-way interactive video chatting, and mobile video chatting. Intelligent information filtering and automatic information receiving are also featured in the platform.

Operational features

The platform use the advanced video and audio integration technologies and has established a multimedia call center by integrating analog voice calls, video calls and SMS text messages. Based on the Internet technology, the platform enables remote real time consultation and communication between experts and farmers.

The multimedia platform allows farmers to consult the experts either through 12316 hotline or video calling with a single click. Farmers can choose which expert they would like to consult if he/she is available. The platform also supports a one-to-eight video conferencing system and the host of the conference can show documents in word, ppt, image, and video formats. This system can also serve the purpose of online training. Trainings can be recorded for future review. Fig. 3 outlines the key system components of One-Click Farmers Service in Shanghai.

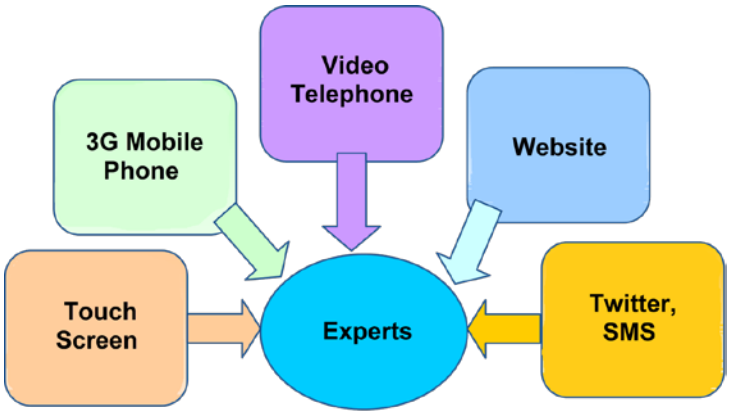

Fig. 3. Key system components in One-Click Farmers Service in Shanghai

Service Outcome

Through advanced information technology, the two-way interactive video service enables a real time "face to face" communication between farmers and experts to solve problems in agricultural production practice. The platform has been further enhanced and now it has connected experts from city and county levels, and reached a seamless video connection between farmers and experts. The platform provides all-year-around consultation services in a simple, direct and easy-to-understand way.

4.6 Mobile Internet-Based Service

Due to the low penetration rate of computers in rural households [25] and high usage of mobile phones in China. This model is developed by taking the advantages of mobile Internet technologies. Users can be connected via handheld devices anywhere at any time. Agricultural information is disseminated to formers on the move or located in any agriculture production sites. The mobile information service is ubiquitous, portable, and geographical identifiable. It has no temporal and spatial restrictions. This service model is expected to dominate the future information dissemination models [16]. According to "China Internet Development Statistics Report" [3] in 2012, 3G network coverage in rural areas has reached 70%, the number of smart phones increased by more than 30% per year in the rural market, and rural Internet users increased to 146 million, of which 60.4 percent of the rural Internet users use the mobile Internet.

Case study- E-Price App

The price fluctuation in agriculture products has increases over years. This has brought negative impact on producers' economic stability and income. The E-Price App is developed to help farmers and agri-business managers to deal with the price volatility. It utilizes the Internet, cloud computing, and smart phone devices. The App releases agricultural products prices provided by a collaborated source from government agencies, agricultural producers, agri-businesses, consumers, etc. The App has functions like price push, price comparison, real time inquiry, agricultural news, location identification, tailor made price reporting, and bidding and match making. The App service provides the price information service in different trading processes such as: production, logistics, retail, agricultural materials, price analysis, etc. Figure 4 shows the home page of E-Price APP. It provides a range of functions for users to select the topic and information reporting format.

Fig. 4. E-Price APP home page

Operational features

The E-Price App provides real-time prices information for users. The price information comes from different sources, including government agencies, communities, enterprises, business units, and individual consumers. Features of the platform include:

1. High user participation. The App allows price reporting by users. Users can act as both a price reporter as well as a price information user.
2. Accurate, reliable, timely updated service. The price information comes from different sources to ensure the accuracy and reliability.
3. Personalized information service. The App allows user customization. Users can subscribe to receive the price information based on their specific interest. The App also has search functions to identify the users' current position and provide location based price and products information.

Service Outcome

The E-Price App is mainly operated by the enterprise in collaboration with relevant agricultural departments. It has been deployed in a number of provinces and cities and will expand its use with comprehensive contents, unified standards, and nationwide coverage. The App has effectively helped the government to monitor and respond to the price fluctuation.

4.7. Unified Multi-Channel Service Model

As each service model has its advantages and disadvantages and suits different application context, an integrated service model has been explored and developed to facilitate information dissemination using multiple communication channels. The success of agriculture information dissemination model requires a two-way flow of information [1]. This unified multi-channel service model incorporates both one way information dissemination (e.g. portal, text message) and two way information interaction (e.g. audio and video communications, online community, and mobile Internet service facilitated two way communications). Currently, each province is exploring the best way to carry out agricultural information dissemination by coordinating different service approaches and models, to maximize the service effectiveness and efficiency.

Case study – "3 in 1 Service" in Fujian

Beginning in 2009, Fujian Provincial Department of Agriculture attempted to unify the information resources and services by integrating telephony voice service, Web applications system, and mobile Internet service into a unified "3 in 1 Service" model. "3" represents landline telephone, personal computers, and mobile phones. Farmers can use these 3 main communication media to access information anywhere at anytime.

Up to now, the voice service has been the most popular information dissemination channel that reaches almost all the rural population in the province. Computer terminals have been deployed in 354 villages. The 3 in 1 service platform provides agricultural consultation, training, agriculture information, etc. The Apps for both Android and iOS were developed to provide similar service functions as those provided by the personal computers. The service platform has 16 service zones covering 46 service categories.

Operational features

1. Sound system development concept. The service model is developed based the concept of "Government-led, demand driven, one central design, collaborative efforts". The project is led and financed by the government and demand driven because the system is farmer-centered in order to meet their needs and be easy to use. It also takes into account of the needs of information and service providers, such as: experts, information officers, etc. "One central design" aims to build one single platform serving as a unified window to provide all aspects of agricultural information services. Collaborative efforts mean that a set of operating mechanism should be established, to enable stakeholders to collaborate when managing and running the platform.
2. Service concept. "3 in 1 service" aims to provide free services to the public in a comprehensive, convenient, professional, and personalized way. "Comprehensive" means telephones, computers, and mobile phones are used together and also information provided covers the whole agriculture supply chains from production to market. "Convenient" means farmers can access services anywhere, anytime using one of three media (landline, mobile and PC). "Professional" means all services are provided by professional staff, so the service quality can be guaranteed. "personalized" means the services are classified based on different user groups and can be customized to meet the user's specific requirements.
3. Active promotion of the service. A number of proactive approaches are in places to widely promote the service in the province. First, the telecommunication enterprises are encouraged to pre-install the App to mobile phones, and offer competitive and affordable subscription packages.

Secondly, all counties in the province are equipped with at least 1 computer and the mobile App is used by the relevant government staff working in agriculture departments. Thirdly, other stakeholders in agriculture related commercial and private sectors are encouraged to use the service.

Service Outcome

The "3 in 1" service platform is still in its early stage. It is expected that this unified service model will significantly improve the coverage of the service areas and quality of services with more comprehensive information sources and quality support.

5. Discussion

Although agriculture information services in China has experienced three major development stages as discussed in section 2, the first stage of the information dissemination service development was mainly for agriculture information processing purposes. Most ICT-based information service models are established in the consolidating and expanding stage since 2000. The three mechanisms of agriculture information service systems described in section 3 can be applicable to all service models.

Section 3 introduces seven information dissemination models used in China and analyzed their operational features and impact on practice. Table 1 provides a summary on the analysis of seven models. All these models are currently in use for agricultural information disseminations in China. From Model 1 to Model 7, the table also demonstrates the advancement of dissemination model by adopting the emerging ICTs. For example, Model 1 was the result of using web pages to disseminate information and Model 6 was based on the ubiquitous mobile Internet technology. Model 7 considers all the relevant technologies and is able to provide a flexible and comprehensive service that suits all user needs. Model 7 described in sub-section 4.7 represents the current application trends in China, but with the rapid development of new technologies, such as Internet of Things, Big Data and Analytics, new information dissemination models will be emerged in the future.

Table 1. A summary of dissemination model analysis

	Information Service Model	Operational features	Applications examples	advantages	limitations
Model 1	Web Portal	a collection of relevant web sites to form a one stop portal for users	China Minister of Agriculture web portal	Easy access, compressive and in-depth information provision	One for all information, No customization. May not be relevant to an individual user's specific information need.
Model 2	Voice-Based Service	information dissemination through phones or online voice calls.	Liaoning 12316 Golden Farming Hotline	interactive communications, easy to understand and individual service	Require human involvement, time consuming and less efficient, more costly.
Model 3	Text (SMS)-Based Service	Disseminating information via Mobile phone texts	Hunan Agri-Telecom Platform	Push-based approach, very effective and efficient in sending short and timely messages	Cannot provide comprehensive and in depth information. One for all service. May not be relevant to individual user's specific information needs.
Model 4	Online Community	A membership system involving all	Farmers Mailbox in	Interactive communications,	Require active user participation, efforts

		stakeholders, share experience and exchange information through interactive service platforms	Zhejiang Province.	relevant information, user participation, cost effective service	and good management. Service is only available for members.
Model 5	Interactive Video Conferencing Service	Information dissemination using online conferencing service	Shanghai Farmers "One Click and Go" service	Easy to understand, very effective communications, interactive service	Require human involvement can be time consuming and less efficient, costs is high due to the involvement of human experts
Model6	Mobile Internet Based Service	information dissemination using Mobile Internet service via smart phones	E-Price App	Ubiquitous, cost effective, easy access, can incorporate GPS technology to provide location related service.	Require adequate infrastructure and the use of smart device. Require higher IT skills to use new technologies.
Model 7	Unified Multi-Channel Service Model	Using multiple models to effectively disseminate information through telephones, computers, and mobile phones	"3 in 1 Service" in Fujian	Flexible service combining advantages of all models	Require Investment in ICT infrastructure and equipment, require more effort and support from key stakeholders

It is important to stress the role of human actor in the success of any information dissemination models. Farmers' ability to use information received has been mentioned as a barrier to information service success by many researchers in China [e.g. 8,10,14] because "information systems consist of human actors and the interactions and the interconnectedness of information resources and behaviors" [18, page 5]. Therefore, human inventions in information and knowledge transfer are critical [18]. As a result, the success of any models will depend on a number of people related factors, such as: farmers ICT literacy, level of awareness and education, motivation, etc. The attitude of farmer towards information and information source and farmer's ability to use information are importance factor for successful use of information delivered to the hands of farmers [18].

Although various surveys have been conducted by regional and local organizations to evaluate information dissemination models, no systematic research have been carried out to understand the impact of these models from end-users perspective. The lack of empirical evaluation of all information dissemination models is a limitation of the current work. Therefore, more studies need to be conducted to evaluate different models based on end-users feedback using rigorous and consistent criteria.

6. Conclusion and future development

The provision of agricultural information plays a decisive role for the overall development of agriculture as well improving the livelihoods of farmers [9,18]. It is argued that information and knowledge are very vital in agricultural development of any community and where they are poorly disseminated as a result of certain constraints, the community's agricultural development becomes highly impeded [21]. Over the last two decades, the Chinese government has invested significant amount of efforts and money in agricultural information dissemination services. These investments have contributed greatly to the agriculture sector's social and economic improvement. With easy access to information, knowledge and experts support through ICT-based information dissemination services, farmers are able to improve their income and economic situation through better practice, for example in dealing with nature disasters, pests, trading, marketing, and with raised awareness of

government support and favorable policies. This paper reviews the current literature on China's information service systems development and implementations, Three distinctive development stages are identified and different mechanisms for developing and implementing information dissemination systems are discussed, which are named as: government-led, market driven and community self-support. Seven information dissemination models are identified and demonstrated with case studies.

After extensive literature review, the key impact of agriculture information services in China can be highlighted in the following areas:

- Improved the efficiency of Agriculture Services, e.g. "12316 hotline", "Unified 3 in 1 services", etc. [19]
- Increased farmers' income [4,9,12,13]
- Improved agriculture productivity [9,11-13]
- Reduced the digital gap between rural areas and modern cities [19]

However, there are still many barriers to the further deployment and utilization of ICT-based information dissemination models due to the following major constrains:

- Poor IT infrastructure and Internet coverage in remote rural areas [9,12,22,23,25]
- Lack of technical support staff [12,23]
- Limited information and knowledge sources [11,12,13,19]
- Management and monitoring system being not fully in place yet [19,23]
- Lack of rigorous information governance and quality controls [19,22,23]

For other developing countries that are still in the early stage of developing and deploying ICT based agriculture information dissemination systems, China's experience, lessons learned and best practice can be considered and adapted. The most important lessons in China can be summarized as the following:

- Government investment and support. This is critical for developing countries because the lack of resources in Agriculture sector [24, 27]. The successful cases in China have demonstrated the essential role of the government investment and support.
- Top-down approach. Farmers have low ICT literacy and are not able to understand the benefits of using emerging technologies for knowledge and information acquisition. Therefore, it is more effective if central, regional and local governments and agencies work together as driving forces and develop initiatives for the adoption of modern information dissemination models.
- Branding and raising awareness. One of the most interesting lessons in China is the success of "12316" information service. It is argued that successful branding and awareness raising via multiple channels has significantly contributed to its success. "12316" has now become a well-known name for Agriculture Information Service in China.
- Motivating farmers to adopt the service, e.g. by providing free services, opportunities to report fraud and illegal products, etc.
- Government and enterprise collaborations. The long term solution for sustainable agriculture

information service models will need the close collaboration between government and enterprises.

- Effective use of village based networks and designated information officers. This is another important lesson learned in China. Local information officers can act as an information broker between knowledge source and local farmers. They are able to absorb knowledge and information received and understand the actual needs of farmers. Therefore they are able to disseminate the required and relevant information and knowledge to farmers effectively.

Looking forward, the success of the future development and deployment of Agriculture information dissemination systems will need the elements of technology, supporting environment, and people working together.

From technology perspective, with the popular use of 3G and 4G technologies, we can expect improved functionality and enhanced user experience in agricultural information dissemination. For example, 3S (GPS, Remote Sensing, and GIS) technologies will also be widely applied in agricultural informatization. Agricultural information in its nature has a spatial component, so 3S technologies which deal with spatial data would be very useful in enhancing agricultural information service. We have already seen many effective agricultural information systems where 3S technologies are integrated, e.g. intelligent fertilizer formulation system. In the future, all of these emerging ICT will play a significant role in agricultural informatization.

From supporting environment perspective, the most important factor is the government support in terms of Agriculture Informatization strategy and policy. The Government-lead mechanism discussed earlier would still be dominant approach in promoting the adoption of future information dissemination models.

From people's perspective, human factors have been and will always be critical for the successful adoption and diffusion of information systems. This is absolutely true for deploying agricultural information dissemination models. Many farmers lack the basic skills required to access, utilize, respond to and act on information [1,9,17]. Findings from various project reports in China [e.g. 7,8,22] revealed that farmers' ICT literacy, education level, knowledge and awareness of system's benefits will affect their willingness to access information services and the service effectiveness. Therefore, raising awareness, education and training will continue playing an important role for the future success of information dissemination models.

Having reviewed and analyzed current ICT-based information service models in China, the following suggestions that are relevant to government organizations and ICT developers can be provided for future development and research:

- Consolidating and harvesting the investment made in the last decades
- Regularly reviewing and monitoring the effectiveness of existing strategies and policies with the intention to improve them based on the feedback from key stakeholders involved, especially the information service officers working directly with farmers in rural regions.
- Transforming agriculture sector into the modern digital agriculture to further improve social and economical benefits
- Further improving the digital access by farmers with technological advances and skills improvement

- Adopting the Internet of Things in agriculture sector, e.g. GPS, GIS, RFID, Remote sensing, Smart device for precision agriculture, sustainability, environment, food safety, etc.
- Exploring and utilizing Big Data and Agriculture Analytics

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